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The Practice of Industrial Hygiene

—Cummings Memorial Lecture—

PHILIP DRINKER, Ph.D.,
Professor of Industrial Hygiene,
Harvard University School of Public Health

DONALD E. CUMMINGS, whose memory we honor this evening, was a chemical engineer by profession. He was sent to the Massachusetts Institute of Technology as a graduate student, from West Point. While at M.I.T. he came down with tuberculosis and went to Saranac Lake for treatment. While there, he caught from Dr. Leroy Gardner some of the latter's interest and enthusiasm for the problems of industry. As Cummings got back on his feet, Gardner gave him more and more to do and Cummings quickly developed an abiding interest in silicosis prevention.

He never lacked for problems or for industrial contacts, which he handled with skill and tact. Both Cummings and Gardner had come to Saranac because they had tuberculosis. Gardner recovered but Cummings had flare-ups now and then, and it took Gardner's best efforts to keep him from working beyond his capacity. These efforts were not always successful.

Until his untimely death in an airplane accident in 1942, Cummings strove relentlessly to keep the tuberculous individual away from dust exposures. It was Gardner and Cummings together who established so clearly the dangers of exposing the tuberculous individual to siliceous dust. These dangers, of course, had been known before, but these two men demonstrated practically and quantitatively the dangers and how they could be avoided.

Both of these men were good teachers. The symposiums established by Gardner at Saranac were the technical meeting ground for all problems of the pneumoconioses. The transactions of these meetings became the accepted books on the subject.

I had the pleasure of a good many years of association with both these men. This evening I would like to reminisce a bit about things that would have interested them if they were here today. Perhaps it would be better frankly to say that I shall do a little thinking out loud, but I'll try to keep my thoughts in line and not stray too far afield.

The word "hygiene" implies control of one's well-being, while "health" defines one's status at the moment. We are in good or bad health. The Surgeon General reports upon the health of the nation. The medical director of an industry reports upon the health of the workers (and he may even include their families). These reports are based upon the results of medical practice.

Industrial hygiene is concerned primarily with prevention. It is the duty of the industrial hygienist to determine the causes of, and to prevent, industrial illnesses, not to diagnose and treat them. He reports upon the extent of the hazard, if any exists, and its control.

The industrial hygienist may be able to define etiology or cause of industrial illnesses better than the medical practitioner. If this state of affairs results in a bit of duplication, or confusion even, it does no harm. Clearly, the person held responsible

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for prevention must ferret out the cause, if he is to see that his preventive measures are put into force.

Is the practitioner of industrial hygiene a physician, like Dr. Alice Hamilton, or an engineer, like Donald Cummings? I say he can be either one.

Criteria in Industrial Hygiene

THE INDUSTRIAL hygienist's most convenient criterion of working conditions is the nearness with which the worker's environment approaches the ideal. We measure the quality of the environment by our arbitrary specifications. In the United States these specifications are set up by different committees chosen from the qualified personnel of the nation.

The application of new kinds of radiations has resulted in specifications to cover all expected exposures of workers—a national committee formulated specifications which were issued through the Bureau of Standards. The American Standards Association for some years has been issuing specifications for maximum allowable concentrations of various toxic substances. The American Conference of Governmental Industrial Hygienists annually revises and reissues a list of permissible concentrations. The American Society of Mechanical Engineers has specifications for permissible stack emissions from power plants. The Illuminating Engineering Society has sponsored specifications for illumination, both domestic and industrial, and these ultimately have been issued by the American Standards Association. It is likely that the Air Pollution Conference in Washington, May 3 to 5, which is national in scope, will result in specifications for permissible outdoor pollution. Such specifications have been broached already by the Los Angeles air pollution authorities.

Today we have specifications governing the purity of water, milk, food and various drugs. These have the force of law behind them. Why should we not have the same degree of hygienic protection from air-borne contaminants and from unfavorable working conditions? The trend in this direction is, in my opinion, definitely indicated.

One often meets with a timid reluctance on the part of some of our colleagues to set limits for pollution, even though many of the figures now used in State codes presently have the suggestion if not the actual force of law. I have no sympathy with such timidity. If you are practicing industrial hygiene and refuse to state what conditions should be attained, you are simply evading your issues. If you ask your doctor what regime you should follow and he won't tell you, the chances are that you'll get another doctor. I am fully aware of our great lack of data in establishing, and of the many practical difficulties in attaining, satisfactory standards of air cleanliness, but I insist that standards must be sought if we are to make intelligent progress in this field.

Our opinions vary as to the precise figures or limits we use, but most of us now use these limits in our routine work. Yet we recognize the limitations of these quantitative figures. I think we should supplement our appraisal of working conditions by personal observation and by every illustrative means at our disposal.

Suppose you were asked to depict to an intelligent lay group, such as state commissioners, officials of a company or of a union, working conditions on a certain property. Is it a good place to work? When you are asked this question, if you do not know the place well you'll probably ask to see some figures on air contamination, lighting, temperature and humidity. If they have no figures you might go and get your own, taking samples yourself and making the required determinations. Perhaps you'll be lucky enough to see a formal report by a reliable State industrial hygiene bureau or perhaps from industrial hygienists in a good insurance company. Suppose you conclude from these data that conditions are satisfactory.

Then you must explain to the commissioner or the others that to the best of your knowledge the company maintained conditions in accordance with modern recommendations. As proof thereof you might cite the report upon the analyses, or your own or the State's data. Do you think this is very convincing? I have done it. I have heard plenty of others do it, and it usually has failed to impress me and often fails to impress the commissioner.

I have compared the effects of such testi-

mony in court—presumably expert testimony—with that of intelligent workmen who told what the place was like in simple terms of how far you could see—did it bother your eyes—did it make you sneeze, and did you mind working there—was there much of a labor turnover? Invariably the "$64 question" was: "Would you tell your son, brother, wife or daughter to work there?" That is a statement everyone understands—employer, commissioner and union official.

In my opinion, simple photographs of conditions with candid camera shots of workmen and of routine operations are usually better for explaining actual conditions than are impressively bound reports dressed up in the best of technical language. The effects of such photos on the workmen, and especially on the foreman, are often dramatic. For instance, depicting bad conditions on the safety bulletin board, with a caption asking for identification of the job, is very likely to result in a prompt clean-up.

An employee of a mining company by whom I once was retained, brought suit for an alleged occupational disease which he claimed to have acquired by breathing a mineral dust. He sat on a stool and picked off a conveyor belt pieces of wood which were occasionally mixed with wet crushed ore. The place was about as dust-free as was obtainable by modern methods. It was clean by any standards. It fell to my lot to explain in court why we had no air dust values for this particular work place. My excuse was actually that we had taken such samples year after year and finally quit because the place was always clean, in contrast to other portions of the plant, some of which were admittedly dusty. We had a complete file on the dusty part of the plant. Why waste time testing the clean places?

The lesson I learned was taught me the painful way because I knew I had been unable to show what conditions were like in a place where a man worked regularly. You can't always tell which places are important and which are not. But you must be ready to describe what conditions are like wherever men work. You'll miss some, do what you will, but the misses must be infrequent.

Costs

WE LIKE to get full value from money we spend, including taxes. Industrialists will spend on plant operations more or less following the law of diminishing returns. How much is reasonable for them to spend on industrial hygiene? Should industrial hygiene money be spent within the medical department, the welfare, the personnel, the production, or what?

In my experience, it depends on how the company became industrial hygiene conscious. A company which is alert to the trends of the times, to labor movements and labor thinking, to industrial medical developments, and the trends in mechanization, is usually easy to convince that it has a place for the practice of industrial hygiene and it expects to pay a reasonable price.

The company which suddenly wants industrial hygiene as an aid in fighting law suits and claims will pay high at the moment and then lose interest and taper off this activity as the damage suits are settled. As a claim-fighting aid industrial hygiene is only moderately useful, and the same is true of the medical department. But if either the industrial hygiene or the medical department actually gets branded as a claim-fighting aid, its practical usefulness is much reduced. The industrial hygienist has to have a lab and good facilities. Perhaps he can share a technician with the medical department and thus save a bit of operating expense. Both departments need many of the same books and periodicals, both attend the same kinds of professional meetings, and both must contribute to the literature. How much do these extracurricular activities cost? Not an impressive amount but they add immeasurably to the prestige and pride in the jobs. I happen to have been in this work almost 30 years, so I have had a fair number of inquiries by young friends and by our own graduates about the advisability of taking such-and-such a job. I always try to find out on what level the prospective employer places a job. Very likely it is a brand new job. I try to get the employer to see the job in the dignity with which we view it or else tell the young man not to take it.

State jobs of this kind generally pay a bit less—say 10 to 20%—but many of the

Federal jobs are equal in pay to those in private industry. The inducement by the government agencies is somewhat greater security, but with industrial pensions and retirement schemes becoming the rule rather than the exception the security of industrial jobs often is just as good as those of the State. Some of our States have reduced their industrial hygiene activities and most of them now depend heavily upon Federal support. Will Federal support to State bureaus continue at its present level?

Most of the large insurance companies practice industrial hygiene and have well developed departments, whether they carry industrial compensation insurance or not. Metropolitan Life, for example, has been a pioneer in the practice of industrial hygiene and industrial medicine because of its group life policies—policies in which the company insures the lives of the employees of an entire organization.

How much do these jobs pay? Our young graduates today get from $4500 on up, depending on their experience—$6000 and $7500 are common. Although our professional numbers are small, I know of quite a few men now getting well over $10,000. Industrial physicians starting in with large companies generally are older and their starting salaries are a bit higher —$8000 is not unusual, while their graduation into the $12,000-class is to be expected in a reasonably near future.

How large does a company have to be to make industrial hygiene or industrial medicine worth while? Obviously it depends somewhat on the nature of the work, but today the trend is toward the practice of both industrial hygiene and industrial medicine in companies of all sizes—full-time personnel for the large and part-time for the small. A very practical scheme for part-time industrial hygienists is through the insurance companies carrying workmen's compensation. Private consultants, either engineers or physicians, do some of this part-time work, but vastly the greater part is done through the permanent set-ups in insurance companies.

Technological Changes and Industrial Hygiene

THE HISTORY of industry in the United States has always shown us to be a nation eager to adopt labor-saving devices. We scrap machinery for improved models long before the old ones are worn out or repairs are unduly high. We estimate depreciation at anything from 5 to 100%. The 5% is low, while the 100% applies to an industry in which models, like automobiles, change before the machine is worn out and before it starts on its "irresistible march to the junk heap."

How much should an intelligent and progressive firm spend to replace a workman? Suppose the man's job involved the risk of serious accident or of an occupational disease. Surely that would encourage the manufacturer to spend more for the mechanization than he might otherwise. How much more? These are questions I recently asked professional and personal friends in various walks of life—mining and smelting, textile processing, insurance companies, and state industrial hygiene bureaus. The replies were very interesting and I'd like to give you a digest of the answers.

The successful firm today is very conscious of its labor relations. It will not countenance the promiscuous replacement of veteran workers by machines unless new jobs are provided. Generally they can be provided. In some instances, labor agreements have a definite proviso to take up labor thrown out by reason of new mechanization. These are demands which have come in gradually and I think they are demands with which the intelligent employer is in sympathy.

I have heard it said that there is no limit to what an employer should spend to safeguard the health of his workers. I doubt this because I think there is a limit. Why not put a money value on Man? He is vastly our most valuable national asset. Life insurance companies put a money value on man from birth to death. There is an accepted valuation for loss of a finger, a leg, one eye or both eyes. There is a definite cash value therefore for partial disability or for total disability. Admittedly plenty of workers overcome the handicap of these losses—that is, either partial disability or total disability—but society has accepted the general idea of compensation in proportion to the loss of earning power the injury causes.

In my own State of Massachusetts a workman can get up to $30 a week and in New York $32 for total disability, and this can continue as long as he lives. In addition, both states require reasonable medical bills, including hospitalization, to be paid. From an insurance standpoint, therefore, a man getting silicosis at, say, age 40, could require the setting up of a reserve of at least $30,000 to take care of his $30 a week for the rest of his natural life, and probably that much more to take care of his total medical expense.

In the case of a man getting a temporary total disability, like lead poisoning, from which he recovers completely at the end of a reasonable period, say one year, compensation would then be at this same rate—namely, $30 a week, or $32 in New York, and medical bills. There may be an additional charge if the man with lead poisoning returns to another occupation at reduced pay. Suppose for instance the doctor of the company says that the worker who had lead poisoning can work again but should avoid all exposure to lead dust in the future. The only job they can give him is at less pay. This difference then has to be made up to the man and such a make-up is required by law in practically all states.

Dublin and Lotka's book, "The Money Value of Man" (Ronald Press, 1946), gives us in tabulated form the cash value of a man, that is the average man, in accordance with his potential earning power. For instance, what is a reasonable and fair compensation to a machinist of age 40 earning $3500 who loses a foot? The experts say he is 50% disabled for life, so that his wages would be cut from $3500 to $1750. Before his accident his gross future earnings were estimated at $54,000, but at an annual earning rate of $1750 his future earnings would be only $23,800, so he stands to lose $30,200 as the result of the accident. If this accident was non-industrial, he probably would recover at least $30,000, from which he pays medical costs. If it were industrial then medical costs are automatically paid for him and he gets the scheduled award.

Ask yourself what you would expect for compensation if you had the misfortune to have such an accident or to acquire an industrial disease which was incapacitating. You'll find your figures are not infinite. You put a cash value on yourself and on the accident.

How much can we expect an employer to estimate as the money value of a healthy workman?

Assume a wage of $3100. Cost to the employer is about $4,000. If we capitalize this at 15% it would be worth $\frac{100 \times \$4000}{15}$ or $27,000 to eliminate a workman. This disregards entirely any matter of ill health or accidents from the job. In general companies today expect to get their investment back from new machinery or new processes in something like 10 years. One large firm told me that they would not invest substantially in technological changes to reduce labor force unless the investment paid off in three years.

Let's carry this general thought further with some practical examples which probably fall within the personal experience of many of you.

Suppose a firm in the general contracting business has a fleet of trucks of varying ages and mileage. They depreciate this investment at something on the order of 20% (or even 40%). (Uncle Sam's mail trucks are a notable exception!)

The contractor's present trucks are worth about $5000 each when new. Suppose by the addition of a $2500 device he can reduce loading and unloading time greatly and also reduce repairs. The firm then balances up the pros and cons of this possible new investment ($2500) without much reference to anything but the practical costs. Manpower is in the background in making the decision.

Now let's assume a contract accepted by this firm calls for running a six-lane highway through hilly country, involving considerable cutting, filling, and one or two sizeable tunnels. The contractor is shown a new type of rock drill that triples the amount of rock, hard or soft, that he can handle per rock driller. The company carrying his compensation has written in a clause in his insurance contract, requiring dust counts from rock drilling to be less than 10 million particles per cubic foot if the rock contains over 10% free silica—that is, the New York State code. Both

carrier and contractor are convinced that the new drills assure compliance with this dust code. Then how much money can the contractor reasonably invest in the new kind of drilling equipment? Obviously much more than in the first example, where neither health nor accidents are involved.

Wages of three men at $4,000 for 10 years are $120,000. Let's assume that one of the three would have gotten silicosis formerly—they certainly wouldn't all have gotten it—and that his disability is carried for 10 years (it could easily have to be carried for 20 years). We could call that figure $30,000 (compensation plus medical costs). This makes the total $150,000 without interest charges and that certainly is conservative. This means a $15,000 year charge if we intend to pay for the new installation over a 10-year period.

Take another more common type of industrial mishap—lead poisoning—from which the worker usually recovers completely. Suppose a company makes storage batteries and four men out of his 100 employees get lead poisoning as a result of which they are disabled totally for four months. Set their wages at $60 a week each. If four men actually got lead poisoning and were awarded total temporary disability it could easily amount to $30 a week per man and extend for four months. At the end of that time they might be returned to a different job at reduced pay because it would be felt that returning to the old job would offer an undue risk to these men until they were completely recovered. Suppose, as is likely, that this new job pays less than the original one. Then the employer makes up the difference and adds it to the compensation costs. Let's assume this period of readjustment extends another four months, which is not unreasonable. This means that the total period of disability or recovery therefrom is actually eight months—call it 32 weeks. Four men at 30×32 makes $3840. Medical costs would come close to doubling this, giving an over-all cost of $7680.

The remedy in this case is probably better housekeeping, with vacuum sweeping, and use for a few hours daily of approved respirators by a small group of workers—not miscellaneous use of respirators in the plant. Routine medical checks of workers would be essential and it all could easily be kept within the $7680 compensation costs.

It is very likely that the battery manufacturer would try to mechanize his dusty process to eliminate these four men. The reason back of such a move is not much different from that confronting the road contractor. If we add four men's wages over 10 years then the investment of a sizeable sum for mechanization is not at all unreasonable.

It has been my experience that employers are very likely to underestimate the labor-saving gain from carefully thought out improvements in processing. It's a commendable sort of error. I always like to think of the employer's ideal—getting several times the estimated production at a small additional cost in men or machinery. Isn't that almost an American motto? It's always what is pointed out to us with something akin to envy by industrialists who visit us from abroad.

Isolating a man who has a dusty or gassy job has had some conspicuous successes. Sandblasting used to be a dangerous job and now is a safe one. Operation of crane cabs above the floor of foundries and miscellaneous furnace rooms used to be a very unpleasant job. Today we have air-conditioned crane cabs with the operator seated out in front in a blister, reminding one of the pilot's seat in a bomber.

Associates of mine had a problem recently of controlling dustiness in a large house, handling a considerable tonnage on the day shift and no rock at all on the other two shifts. The rock handled varied around 10% free silica. There was no reason save hygienic to keep dustiness down to the accepted level of 10 million particles per cubic foot or less. One man was in this building all the time and another part-time. Good dust control would cost at least $60,000. It is proposed instead to install ventilated booths for the men, have them wear respirators when out of the booths and keep dustiness down only to 100 million. This we can do at a reasonable cost. If this particular building were destroyed, as by fire, and were to be rebuilt, dust control could certainly be installed for about half what it costs in the present building.

I remember very well when my former

associate, Professor Hatch, was designing dust control equipment for an old granite shed not far from Boston. These sheds are built on an arc so that stones can be swing in conveniently on the boom of a crane placed in the center of the arc. Each shed has a hinged roof which is lifted up when the stones are moved in and taken out. There are no doors or windows—just New England, and plenty of that on cold days! Hatch's estimates of dust control on this job ran to figures many times the value of the shed and its contents. The result was that the firm, a very progressive one, built a new plant, and the dust control equipment went in on the drawing board. The cost of that kind of control is reasonable.

What standards of air cleanliness should we use when the contaminant is harmless, by all present knowledge? Good examples are acetone, as a vapor contaminant, and limestone as a dust. If you glance at the MAC for acetone you'll find it placed at 500 ppm yet there are plenty of practical plant data indicating no adverse effects at 2500 ppm. At not much above this figure we begin to consider the fire risk and the danger of mild anesthesia. I would use the figure of common sense—the one you'd expect to use on my hypothetical lay audience —the commissioner, the plant executive or the insurance leader; 500 ppm is too low but 2500 is too high.

Limestone dust has not been shown to be harmful and we have actual plant and mine data showing men have had long exposures, without harm, to concentrations vastly in excess of the 50 million ppcf required by some states or the 100 million in New York. I have seen concentrations of 500 million and more. This dust, you'll remember is one of the first passed by the Bureau of Mines as being physiologically safe for rock dusting of soft coal mines to reduce the risk of dust explosion. I don't ask for 500 million—that's too dusty in anyone's scale—but I claim the 50 million is uncalled for. A figure of 100 million is attainable by methods which are not prohibitively expensive and is plenty low enough to keep conditions decent within the working area.

There have been a few dramatic instances of pollution outside a plant causing demonstrable health damage of a kind which easily is preventable. I happen to have been associated in one such episode which never went to trial, as the cause and remedy were admitted by the defendant company which stopped the operation. The plant was located in a busy industrial area across the street from a foundry. The plant was engaged in a general fertilizer business and had built up quite a market for castor bean dust from the dried residue from expressing castor oil. This dried dust will cause a violent reaction among a fair percentage of persons who breathe it: about 10%. It could be caught easily by filters or by dust respirators and being an organic residue could be destroyed completely by heat. The workers within the plant who were sensitized to the dust simply left and got other jobs, but the sensitized workers in the neighboring foundry were affected when the wind blew in the right direction. In a comparable case in Toledo, Ohio, it was shown that persons as far as two miles from the plant crushing the castor bean dust were affected, and the Toledo plant was closed down by court injunction. With the Toledo experience before us and a full medical report, we advised our clients not to contest the injunction. Of course this sort of problem is a delight to an engineer. The remedy is simple, inexpensive, and results are certain.

Pollution outside the plant has been brought prominently to the attention of the public by the Donora episode. Pollution troubles outside the plant are an old story to the non-ferrous smelting industry. I have always felt that such pollution problems were definitely our job and fell distinctly within the practice of industrial hygiene. Formerly, damages paid for outdoor pollution were mostly for property damage. Recently there have been large awards for damage to cattle, especially dairy herds, and sheep. Damage to buildings and awards therefor, are not uncommon. As we all know claims have been filed against the company at Donora for allegedly affecting the health and life of its neighbors.

Recirculation in Industrial Ventilation

THERE IS a general feeling against recirculation in industrial ventilation

problems, where a dust such as silica or some toxic solvent is involved. I think the time has come to modify the laws which prohibit such recirculation. We have brought remedial equipment to the point where it seems to me that such recirculation should be demanded. There is no reason to prohibit it providing one has assurance that no harm to any one will result from this recirculation.

I note with great interest that Mr. Stern is presenting a paper at the meetings on April 27th on this very topic. New York State, in whose bureau Stern is, is the first, so far as I know actually to face this issue and to encourage industrial firms to use recirculation. It is a fruitful field for industrial hygiene engineering and one in which we should be able to save money for the employer, especially when the installation is in cold climates.

Premium Pay for Extra-Hazardous Job

IT IS GENERALLY accepted in industry that extra-hazardous jobs such as that of the of the steeple-jack, the deep-sea diver, the caisson worker, and the aviator get extra pay because of the risk they accept. The argument is that man is unable to make the job safe. If the employee chooses to accept the extra risk he should be awarded accordingly. I have no fault to find with that argument. It is unfortunate that it should be extended into fields where the danger is either unreal or is one which can be removed—for example, during the war extra pay was given men who welded on galvanized iron because of the annoyance to them of occasional bouts of metal-fume fever. Extra pay was given to men who handled certain types of glass or wool-slag insulation. It was alleged that this was a nuisance to handle and that it might harm the worker because of the annoyance from the tiny spicules of glass wool. Many other examples can be given. I contend that when a job is annoying or even hazardous, if the annoyance or the hazard can be removed then the premium pay should be removed. So far as I know, this virtually never is done. The premium pay is awarded as the result of concerted action by labor, but labor virtually never helps to remove the extra pay when it is no longer justifiable.

The amount of money involved in these premium awards is probably not great, but the awards are a reflection upon the efficacy of what we attempt to do in industrial hygiene. It is something that the industrial hygienist should note and, wherever he can, he should try to get it cured.

Professor Philip Drinker, left, receiving the Cummings Award for notable service in the field of industrial hygiene, and E. C. Barnes, right, then president of the American Industrial Hygiene Association

The Elimination of Background Color in Colorimetric Determination of Cyanides and Hydrocyanic Acid

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THE PRESENT colorimetric analytical methods used in industrial hygiene for the determination of cyanides and thiocyanates are unsatisfactory in the region of 0.25 to 2.5 micrograms per cc, which is the critical region for industrial hygiene work. The reagent used in the methods for the development of the red color is prepared with ferric chloride and hydrochloric acid. The intense yellow background obliterates the red color developed by micro amounts, thus producing a flat, standard curve which prevents any accuracy below five micrograms per cc. It has been found impractical to add an equivalent amount of ferric chloride to an unknown in order to eliminate the yellow background.

A study was undertaken in this laboratory to eliminate the yellow background by varying the acid and the anion of the ferric reagent. It was found that the yellow background was materially eliminated by substituting nitric acid for hydrochloric acid and was completely eliminated by changing the anion of the ferric reagent to ferric nitrate in conjunction with the nitric acid. Three solutions have been studied: ferric chloride and hydrochloric acid, ferric chloride and nitric acid, and ferric nitrate and nitric acid.

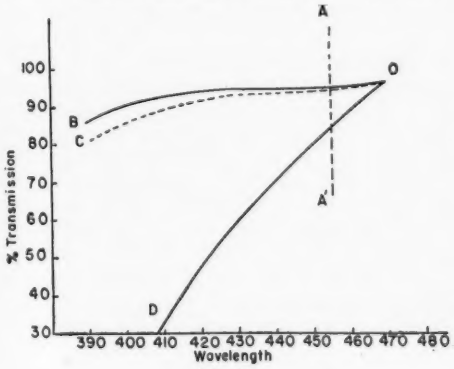

Fig. 1.
Spectral Transmission Curves

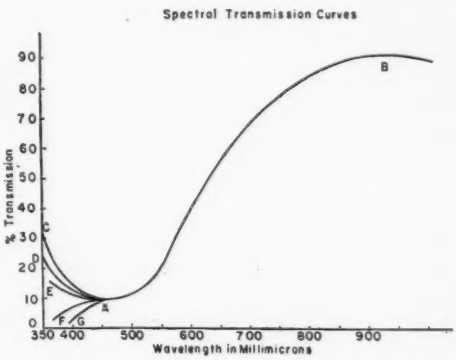

Fig. 2.
Spectral Transmission Curves

Fig 1 shows the spectral transmission of the background color of the three reagents. It is seen at A-A' (455mu, the wave length used for the determination of thiocyanate) that there is an 18% loss in transmission in the ferric chloride and hydrocloric acid, while there is little or no difference in the absorption of the ferric chloride and nitric acid and the ferric nitrate and nitric acid. Fig. 2 shows the spectral transmission of the thiocyanate with several solutions. Regardless of the solution used, the absorption of the solution between points A and B are the same. Point A (455mu) is the point of maximum absorption. It is seen that curve DAB varies only slightly from that of the ferric nitrate and nitric acid curve CAB, while curves EAB, FAB, and GAB are ferric chloride and vary markedly. Each curve is an increase in ferric chloride with a subsequent increase in background color. All of the curves have been extrapolated to curve CAB in order to show the similarity and the deviation of that portion of the curve to

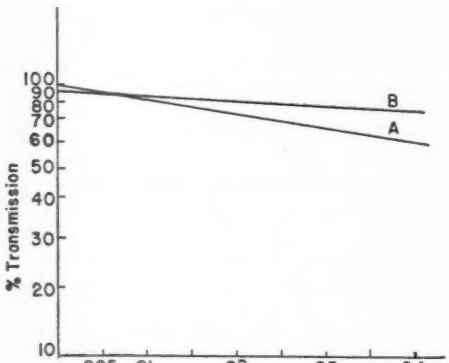

Fig. 3.
Calibration Curves

the left of point A. Curves EAB, FAB, and GAB actually coincide at point marked as H, which is approximately 6% transmittance.

In order to show how this is applied to the analysis of thiocyanate, Fig. 3 shows the standard curves obtained when the three reagents are used. Ferric chloride and hydrochloric acid give a flat curve which leads to errors in the analysis while ferric chloride and nitric acid, and ferric nitrate and nitric acid (Both on curve A) give a more accurate curve.

An exhaustive search of the literature revealed the fact that biochemists and others have been using HNO_3 for the acidifying agent in the determination of thiocyanate for a number of years 1, 2'*. In some cases the use of HNO_3 has been reported in the determination of iron by the thiocyanate method and in indicator reactions volumetric analysis of silver. In view of these findings, we believe that it is advisable for industrial hygiene chemist to adopt the use of HNO_3 in place of hydrochloric for the acidifying agent in the determination of cyanide and hydrocyanic acid by the thiocyanate method.

Summary

THE EVALUATION of the methods for the determination of cyanides and thiocyanates are discussed in the presence of hydrochloric and nitric acid. The advantages of nitric acid are shown and the reasons for each reagent are discussed.

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* This illustrates rather forcibly the lack of coordination of analytical methods between the various branches of chemistry. Even though nitric acid is used to intensify many other color reactions, HCl is still being used in a great many laboratories.

Some Industrial Hygiene Problems in the Petroleum Industry

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OBVIOUSLY all of the various industrial hygiene problems associated with the activities of the petroleum industry can not be included in the scope of this discussion; however, an attempt will be made to describe certain typical problems that are associated with selected refinery and other procedures.

Before any crude oil reaches a refinery for processing, it must be removed from the ground and transported to refinery locations by various methods. There are a number of health problems which arise in the course of producing crude oil. In many areas where oil fields or refineries are located, housing and similar facilities for workers are either inadequate or totally lacking. This applies to both domestic and foreign areas; therefore, in some cases, it becomes necessary to develop such items as housing, water supplies, sewage disposal, insect control, garbage disposal, and other features of general community sanitation. This problem may vary widely in its extent from a situation involving a half dozen houses up to construction, operation, and maintenance of facilities necessary for a population of several thousand. In developing such facilities, naturally, certain public health aspects are involved; and these must be given due emphasis in order to insure the proper protection of the employee health. In some cases, particularly in foreign areas, a staff of sanitary engineers may be required for the handling of such problems.

TABLE I
SOME INDUSTRIAL HYGIENE PROBLEMS AS RELATED TO PRODUCING CRUDE OIL

1. Camps
   a. Water Supply
   b. Sewage Disposal
   c. Insect Control
   d. Garbage Disposal
2. Exposure or Hazard
   a. Radioactive Materials
   b. Hydrogen Sulfide
   c. Mercaptans
   d. Anti-oxidants
   e. Special Inhibitors
   f. Solvents
   g. Tars
   h. Dermatitis
   i. Carbonyl Sulfide
   j. Others

In the drilling of wells, servicing and maintenance of equipment, and in connection with pumping and pipeline operations, employees may be exposed to certain toxic materials. These might include such things as radioactive compounds, hydrogen sulfide, mercaptans, anti-oxidants, special inhibitors, solvents, tars, carbonyl sulfide, and others. Such exposures may be either acute or chronic, depending on the nature of the job at hand.

Processing Procedure Problems

THE GREATEST number of industrial hygiene problems are associated with processing procedures. Only a few of those that are found in certain refinery activities will be confined to certain of the more specific about how exposures occur and

COURTESY OF STANDARD OIL COMPANY (NEW JERSEY)

Fig. 1.
Acid treating area. In this area crude oil is treated with acid to reduce the impurities in the crude. The workers in the foreground are emptying a vat

under what particular conditions, remarks will be confined to certain of the more general aspects of these situations.

The type of toxic materials to which workers are exposed may be governed to a certain extent by the characteristics of the crude oil being handled, and by the nature of the process, design of equipment, and materials, such as catalysts and the like, required by the processing unit. However, a number of more or less general problems may be associated with a group of refinery procedures. For example, if sour crude, containing appreciable amounts of hydrogen sulfide, is being handled, straight distillation may present exposure to such compounds as hydrogen sulfide, mercaptans, carbonyl sulfide, sulfur dioxide, carbon monoxide, and others. In many cases, the operators of the units themselves may not be involved in frequent or serious exposures. Exposure of operators may take place, however, when samples are being collected, units are on test runs, or where leaks may develop in lines, valves, pumps, and the like. On many refinery units, it appears that the maintenance men may be subjected to more of an exposure than is the case with the actual operating personnel.

The same general type of exposures, as outlined above, may occur in cracking operations, both thermal and catalytic. If catalytic cracking is considered, then exposure to catalyst dust is encountered.

TABLE II
SOME INDUSTRIAL HYGIENE PROBLEMS AS RELATED TO REFINING

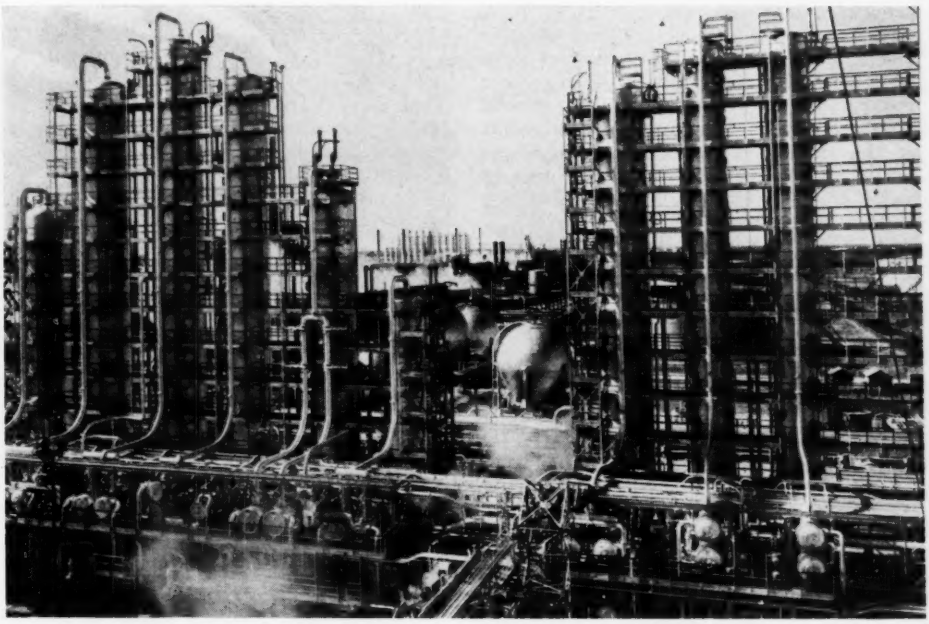
Process or Operation	Exposure or Hazard
Distillation	Hydrogen Sulfide
1. Pipe Stills	Carbon Monoxide
2. Batteries	Sulfur Dioxide
	Mercaptans
Cracking & Polymerization	Aromatics (Toluene
1. Thermal	Cumenes, etc.)
2. Catalytic	Noise
3. Hydroforming	Carbonyl Sulfide
	Ammonia
Light Ends	Aromatic Amines
1. Absorption	Heat
2. Fractionation	Hydrocarbon Vapors
3. Debutanizers	Catalysts
4. Alkylation	Dusts
5. Isomerization	Others
Others	
	Lead Oxide
	Aromatic Amines
	Acid Mist (H_2SO_4)
Chemical Treating	
1. Lube Oil	Sulfur Dioxide
a. Phenol Extraction	Toluene
b. Propane Dewaxing	Ammonia
c. Acid Agitators	Hydrogen Sulfide
d. Solvent Dewaxing	Mercaptans
e. Clay Contacting	Dermatitis
2. SO_2 Extraction	Inhibitors
a. Kerosene Stock	Oxides of Nitrogen
b. Other Fractions	Heat
3. Light Oils	Benzol
a. Gasoline	Methyl Ethyl Ketone
b. Kerosene	Phenol
c. Varsol	Inorganic Dusts
d. Naphtha, Heating Oil, etc.	Carbon Tetrachloride
	Mercury
4. Others	(Others)

Light Ends Department

MANY OF the low molecular weight volatile hydrocarbons, from such operations as distillation, cracking and the like, are sent to what is known as a light ends department. The units involved in this work may include absorption and stripping towers, fractionators, debutanizers, alkylation, and isomerization equipment. Since many of the more volatile materials from other refinery areas are sent to this area, the principal exposures will come from such materials as hydrogen sulfide, mercaptans, and hydrocarbon vapors. In case high sulfur crudes are handled, the problem with hydrogen sulfide and other sulfur bearing compounds becomes increasingly important.

In the chemical treating of various materials, toxic compounds are used; and certain exposures develop. There are a number of procedures for chemical treating incorporated into refinery operations. For example, in the preparation of lube oil, stocks may be treated with phenol, propane, acid, and with solvents for dewaxing. On the other hand, the chemical treating of certain light products may involve exposures to such things as lead oxide, aromatic materials, mercaptans, and others. Probably one of the most characteristic exposures incident to chemical treating is sulfur dioxide and mists from sulfuric acid. This is particularly true in the case of acid treating lube oils. The problem of sulfur dioxide may be further extended by procedures for removing acid sludge and for the concentration of weak acids.

A number of exposures to toxic materials may be associated with the few refinery operations which were noted above. These operations and exposures represent only a small part of those found in a refinery as a whole. The number of processes mentioned may be multiplied many times in de-



COURTESY OF STANDARD OIL COMPANY (NEW JERSEY)

Fig. 2.
A Light Ends Fractionating Unit

scribing the operations as carried out in the refining of crude oil, the manufacture of various products, and the production of petroleum chemicals.

Complex Chemical Operations

FORMERLY, the petroleum industry was concerned primarily with producing crude oil and refining this by methods consisting pretty much of straight distillation. In the past several years, more complex technology has come into petroleum processing; and now the petroleum industry truly represents a highly complex chemical operation. Many of the products coming from refining and other methods of manufacture are essentially those found in straight chemical industry. Along with the development of new refinery process methods for the production of various materials, have been introduced the associated environmental exposures to which the workers are subjected. Many of the materials produced by the petroleum industry are made in other type industries, and the industrial hygiene aspects, associated with these products, are familiar to men in these fields. A few such materials which present industrial hygiene problems would include the manufacture of insecticides, paints, solvents, alcohols, catalysts, synthetic gases, anti-rust compounds, special additives, synthetic rubbers, organic intermediates,

TABLE III
SOME MATERIALS PRODUCED WHICH PRESENT INDUSTRIAL HYGIENE PROBLEMS

1. Insecticides
2. Paints
3. Solvents (Aromatic & Others)
4. Antifreeze Materials
5. Alcohols
6. Ketones
7. Special Catalysts
8. Synthetic Gases
9. Anti-rust Materials
10. Special Additives
11. Tars
12. *Synthetic Rubbers*
13. Organic Intermediates
14. Agricultural Chemicals
15. Mining and Processing Clays
16. Acids
17. Plastics
18. Wax
19. Others

agriculture chemicals, clays, acids, plastics, waxes, and others. It is not necessary to go into details as to the type problems associated with the manufacture of the above products, as they are fairly well known. However, a brief list does serve to point out the variety of materials produced by the petroleum industry and the general nature of the industrial hygiene problems incident thereto.

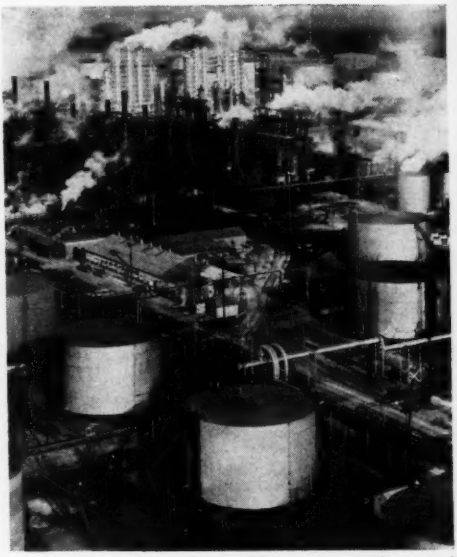
All of the environmental exposures are not associated directly with refining. Many of these come from maintenance and repair operations on various types of refining and manufacturing equipment. Some of the maintenance operations involving exposures include welding, pipe fitting, insulating, brick laying, painting, instrument repair, lead burning, foundry work, ship repairs, machine shops, tin shops, boiler making, and the like. From the standpoint of the total number of employees exposed to either toxic materials or deleterious physical conditions, probably the greatest single group in a refinery is found in the maintenance and repair work. In many cases such individuals are not only exposed to process materials, but also to toxic substances which arise as a part of maintenance or repair work, such as is the case with instrument repair men.

TABLE IV
SOME MAINTENANCE AND REPAIR OPERATIONS WHICH PRESENT EXPOSURES

Operation	General Exposure
Welding	Metal Fume Fever, Fluorides, Heat, etc.
Pipe Fitting	Dermatitis, Solvents, Heat, etc.
Insulating	Asbestos, Heat
Brick Laying	Silica Dust, Heat
Painting	Solvents, Thinners, Lead, etc.
Instrument Repair	Mercury, Solvents
Lead Burning	Lead
Foundry	Silica Dusts, Lead, Brass Fumes, etc.
Ship Repairs (Drydock)	Welding, Burning, Painting, etc.
Machine Shops	Degreasing, Dermatitis, Metalizing, etc.
Others	

Research and Laboratory Activities

THERE ARE many industrial hygiene problems associated with research, development, and laboratory activities. A great number of experimental materials are used, both on a laboratory and pilot plant scale.



COURTESY OF STANDARD OIL COMPANY (NEW JERSEY)

Fig. 3.
A general view in a refinery showing the light ends unit in background

Of the overall materials used many would include such things as toxic hydrocarbons, dusts, metals, catalysts, gases, mists, and the like. In many cases, very little is known concernin gthe toxicity of such materials; and it becomes highly desirable and even necessary to develop a certain amount of toxicological data for research operations.

Frequently the use of toxic materials is considered where such compound may have certain properties which could well be incorporated into products of manufacture.

TABLE V
SOME INDUSTRIAL HYGIENE PROBLEMS ASSOCIATED WITH:
RESEARCH, DEVELOPMENT & LABORATORIES

1. Exposures (Laboratory and Pilot Plants)
   a. Hydrocarbon Vapors (Aromatic and others)
   b. Dusts
   c. Toxic Metals (Pb, Hg, etc.)
   d. Catalysts
   e. Gases
   f. Others
2. Assist with problems involving use of toxic materials in products considered for manufacture.
3. Development of Toxicological Data
   a. Literature Searches
   b. Animal Studies
   c. Other

In such situation, it is often necessary for the industrial hygienists to advise with either research or manufacturing groups as to what problems would result to the customer or consumer if such materials were used in products. In these cases, one is frequently called on to assume a set of hypothetical situations and from this develop calculations on a theoretical basis designed to predict levels of exposure to materials if the final product were actually marketed and used for certain purposes.

Often, a good bit of information is known on the toxicology of materials used in the petroleum industry, since a number of these compounds have been produced by other industries and, in the past, have been studied. However, many of the compounds with which the industry is concerned are either new or have not been studied. Therefore, it is necessary to devlop toxicological data on a great number of such materials. This is done by a search of the literature, by experimentation on animals, by contact with other manufacturers, or by some other procedure.

Summary

IN SUMMARY, it might be pointed out that the environmental health problems in the petroleum industry have greatly increased in the past few years, due, in large, to the development of the chemical manufacturing aspects of the industry. For the industry as a whole, the concept of industrial hygiene is relatively new; and work along these lines is considerably behind similar activities which have been carried out in the chemical and other industries. This probably points to the necessity for a considerable number of basic studies, followed by industrial hygiene which is designed to keep pace with the rapidly expanding chemical phases of the industry.

Maximum Permissible Levels of Exposure Agreed on at Chalk River Conference

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Oak Ridge National Laboratory
Oak Ridge, Tennessee

ON SEPTEMBER 29 and 30, representatives of the Radiation Protection Committees of the United States, Great Britain and Canada met in Chalk River, Canada, to discuss maximum permissible levels of radiation exposure. Dr. Shields Warren of the American delegation acted as chairman of the meeting.

At this meeting it was agreed to base the permissible exposure on a weekly rather than a daily basis, and all the values of exposure to radiation were lowered somewhat. The relative biological effectiveness of fast neutrons was increased from five to ten and the relative biological effectiveness of alpha radiation from 10 to 20 is indicated in the table below.

Radiation as measured on the surface of the body or within the epidermal layer was permitted to be five thirds of the permissible exposure inside the epidermal layer and because of the scattering of radiation by the body the radiation as measured on the surface of the body was arbitrarily assumed to be five thirds of the permissible level of radiation in the working area. An exception was made to the exposure to the hands and forearms in that the exposure in this case was permitted to be five times that in the working area.

Values were agreed upon for several of the more commonly used radioisotopes. Values for the weights of the body organs, rates of excretion and elimination were agreed upon for the Standard Man. These agreements should standardize the calculations on levels of maximum permissible exposure used by various persons making calculations in the three countries.

Official minutes were taken at the meeting and should be available for publication in the near future.

Maximum Permissible Tissue Dose Limits In "Reps" per Week

(Does not guarantee no damage)

Based primarily on experience in lack of damage from 200 Kv X-rays and comparisons with other types of radiation.

Type of Radiation	At any Point Within the Body	RBE*	In the Basal Layer of the Epidermis	
			Exposure of Entire Body	Exposure of Hands Only
X-rays and Gamma Rays	0.3	1	0.5	1.5
Beta Rays	0.3	1	0.5	1.5
Protons	0.03	10	0.05	0.15
Alpha Rays	0.015	20	.025	0.075
Fast Neutrons	0.03	10	0.05	0.15
Thermal Neutrons	0.06	5	0.1	0.3

*RBE=Relative Biological Effectiveness.

For purposes of health monitoring, whole body exposure should be assumed when radiation is received to any portion of the body other than hands or forearms.

In the light of present knowledge no manifest permanent injury is to be expected from a single exposure of persons to 25 r or less with the possible exception of pregnant women.

The Safe Handling of Chemicals in Industry and in the Home

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CHEMICAL injuries are actually a small part of our total picture of accidental injuries. However, like other types of accidental injury they are unnecessary. In other words, we can do something about them. Your problem, like my own, is the responsibility for many people who may handle chemicals. Our problem is then largely one of inducing people to handle them safely that is the heart of my topic today rather than the details of safe practice. You remember the old saying "You can lead a horse to water but you can't make him drink." Our greatest problem is to induce him to drink.

If we are to discus 'chemical substances,' we should consider what they are. We can certainly not rely upon the popular idea that a chemical is a 'dangerous stuff which stinks.' Broadly, everything we use is of a chemical nature. We are really dealing with practically any individual substance which may be used in industry or in the home. But, you may say, we are of course interested only in hazardous substances. Let us then consider what a hazardous substance is. In general, the term poison conjures up lurid visions of witches' brew and black magic. In such matters we must realize that we are dealing more often with emotional thinking than with rational thinking.

Let me give you my own definition of the term poison: "A poison is too much." Now I assure you I am not being facetious, I am very earnest in this definition. Let me illustrate by describing a very simple experiment which time does not allow me to perform for you. We are frequently asked, "Is this substance a poison or is it not a poison?" If we were to ask the individual what he means, he would simply say, "Why give it to an animal, and if he dies it is poison, if he doesn't, it is not." Let us outline a simple experiment by taking four mice and giving them by mouth one of four different substances. Those substances which kill the animal we will classify as deadly poison and those from which the animals show no discomfort, we will classify as entirely harmless. When two of the animals die we examine the record and find that they received the two deadly poisons, table salt and baking soda. The other two animals who lived happily and contented were given the innocuous substances known as strychnine and white arsenic. Now there is no trick or magic to this experiment, it is just a matter of amounts. We gave the animals more table salt and baking soda than we gave of strychnine and white arsenic. This is not a matter of a substance being a poison or not a poison, but it is a matter of whether or not the substance gets into the animal body in excessive amounts. You can readily kill an animal by an excessive amount of table salt or baking soda, but there is no reason in the world why you should. In the same way, we can readily kill an animal with an excessive amount of strychnine or white arsenic or nearly any other material, but there is no reason why we should. We realize of course that the smaller the toxic dose the easier it is to get a toxic amount and the more careful must be the handling precautions.

A CHEMICAL substance is not of malicious intent. It will not, with malice of forethought, reach out and bite us. It has consistent and definable properties. If we ignore these properties and misue the substance, we can expect trouble. We see that we ourselves, in our own acts, contribute an essential part of the pattern leading to injury. Therefore, with more knowledge, and less disregard for the knowledge we have, we can eliminate to a large degree, the hazards of misuse.

There are three basic modes of contact to be considered in the practical problem of handling a substance. The breathing of an air dispersion (dust, vapor, mist, etc.), contact on the skin or eyes (with either irritation or absorption), and entrance by mouth. The practical hazard of breathing air dispersions is not determined solely by

Presented at the Gulf Coast Safety Conference, Houston, Texas, October 7, 1949.

the toxic concentration. The ease of obtaining a toxic concentration is just as important, and this depends not only on the physical properties of the substance but also on the circumstances of use. Whatever the mode of contact and entry to the body, the ease with which excessive amounts may by contacted is more important than the toxicity alone. In other words, the toxicity is not a measure of the "practical hazard."

The "practical hazard" is determined by the physical, chemical, and physiological properties of a substance plus the circumstances of use. The subject of interest to us is actually the "practical hazards" of our contemplated use.

So far I have emphasized the toxic hazard. We should never forget the fire hazard. It has been by all means more damaging to life and property. As a friend of mine expressed it in a general discussion on hazard warnings, "We will blow more people through the windows with carbon disulfide than we will ever poison with it in spite of the fact that it is a highly toxic substance."

In one way we are a step farther ahead in considering fire hazards than we are with toxic hazards. Most people are more realistic and less emotional in considering a fire hazard. We are in general more cognizant of the fact that something can be done about them. However, be it fire hazard or toxic hazard, the basic fault is in misuse.

It is obvious then, that our problem is one of eliminating misuse. In order to do this, we must recognize what constitutes misuse of any particular substance and we must define what is proper use. Even after we have this information, it is necessary that we diseminate this information to the individuals who may handle the substance and convince them to apply safe handling practice.

WHILE there are certain basic similarities between the problems in industry and the problems in the home, there are also certain differences which make it desirable to consider each one separately. Let us then turn our attention first to our industries. In considering industries please remember that the agricultural industries are our important industries, and should not be neglected by those people whose responsibility it is to concern themselves with industrial health and public health.

If you are faced with a decision in regard to the design and operation of a process entirely new to your organization or area, you will probably want to investigate the known information as it appears in the literature. Let us then examine a typical case of a particular substance.

I quote in part from an abstract concerning the use of this particular substance we will call X—"Onychia Due to Handling X." "All but two finger nails of a woman working with X were affected...Some nails were stripped off, others were split and lifted from the bed. Granular tissue could be broken away when the nail plate was lifted...The condition cleared up when the woman stopped her work."

I quote in part from another abstract concerning the industry manufacturing X. "Usually the disease begins with slight fever, chills, and malaise. A localized infiltrated patch appears in the healthy skin, which in a few days develops the characteristic of an extremly painful boil, with lymphangitis and adenitis...Laborers in the X manufacture usually present a squamous dermatitis between the fingers and on the back of the hands...X causes gingivitis...In extreme cases the teeth fall out."

In considering the facts presented by this abstract, you might readily consider that you would be faced with some serious health problems in operating such a plant. However, we note that the substance X is 'sugar.' This puts a rather different light on our interpretation of the fact. In analyzing our own thoughts, then, we realize that we may be as much affected by a somewhat emotional consideration by which we ignore the problems associated with a familiar substance and greatly overemphasize the problems associated with the use of a substance with which we are not familiar. This is not entirely unjustified because we have more reason to be confident of the information on a familiar substance. Too often, however, we find to our surprise that we have more information on a new substance than on some old familiar ones. Many of our older materials are accepted just because we are getting by.

We often observe in people handling chemicals, a respect for a substance with a disagreeable character such as an odor although there are no serious hazards from its use. At the same time we see disregard for the hazards of a substance without disagreeable characteristics although verbal warning has been given of its potential health hazard. In a like manner a workman is often concerned over a small superficial irritation which is an obvious nuisance while apparently unconcerned over serious potential internal injury which may not be physically obvious to him at the moment.

IN APPROACHING the problem of a new process in industry, we obtain what information we can from literature and from the toxicological laboratory as to the physiological effects of the substances. We also obtain as much detailed information as we can about the physical and chemical properties of the substances and the mechanics of the operations in a proposed plant for manufacturing or using these materials. From this information we should be able to put together a picture by which we can determine the possibilities of exposure in the operations and from the toxicological information determine whether or not these potential exposures represent a practical hazard. This is of course much simpler to state in a few sentences as I have stated it, than it is to accomplish in fact. The discussion of the details of working out this problem are beyond the time which we have available today. Let us assume that we have accomplished this survey, and have a pretty good comprehension of the problems which we may encounter and the means of safe handling of the material. How are we going to implement that in our industry so that we are successful in eliminating misuse and misoperation?

The first and most important step in industry is to get our chemical engineers and designing engineers to recognize that the potential hazards involved in the manufacture and handling of the materials are as much a part of the problem of design and operation of a plant as are the physical properties of the substance or, for that matter, the load on the structural members of his building. If we can get the designing engineer and the building engineer to take these factors into account in the original layout of his apparatus, we are making the most important step towards safe operation at a minimum cost.

The second main object to be attained in the industry is to convince the operator that the proper use and handling of a material in his operations is just as important as the control of temperature and pressure in his process, or the productive output of his plant. When the operator accepts the health problems of his operation as part and parcel of the regular operating duties, then we have a good chance of eliminating injuries due to exposure to the substances in his process.

The final answer to our problem in industry comes from the success we have in putting across an understanding of the problems to the people in design and in operation. The attainment of the proper knowledge of the subject is just the beginning.

Please excuse me for a great over-simplification of the problem in industry. But as I want to leave these two main approaches with you, I do not want to go into further detail in discussing the industry's problem. The two factors, first, of accepting toxicological properties of a substance as a logical part of the problem of basic design; and secondly, of accepting problems of exposure as part of good operating technique, are fundamental to the elimination of health hazards in industry.

NOW LET us turn to the home. The greatest difference we have between the industry and the home is the fact that in industry supervision has some control over both the engineering of a process and the individuals in operation. In the home we have no direct control and very few channels for passing on information concerning the safe use of materials.

Recognizing the possibilities of oversimplification, I want to reduce the problem as it occurs in the home to the three factors that I feel are the greatest contribution to accidents with chemicals:

We will recognize that the label, containing the information on the proper use of a substance and any warnings as to certain misuses of the substance, is our most direct channel for informing the in-

dividual in the home. Our first great difficulty is the fact that people neither read the labels nor apply the information contained theron. An attempt to get people to pay attention to the information contained on the package within which they receive the material would be a very great step forward in avoiding misuse of the material in the home.

Our second difficulty is created by improper storage. Mother brings home the groceries including a can of rat poison and dumps them all out on the kitchen shelf with the intention of putting them away later. Meanwhile, little Johnny explores to see what he can find. All substances which are not to be eaten should be stored away from food stuffs and out of the reach of children.

The third major factor is of the greatest importance by far. I refer here to the tendency to transfer various substances to common containers around the house, such as a drinking glass or a pop bottle, which are then left readily available to children or other adults. This is probably the source of the greatest problem in handling substances in the home. Very much in the same category will fall the individual who purchases a small amount of material in the corner store and has it poured out into a pop bottle or other unlabeled, unidentifiable container, which he then proceeds to take home and leave where it is easily available to people who are not at all familiar with its content.

LET'S EXAMINE but one result of such procedure. You will recognize immediately that it is not the most hazardous substance that causes the most difficulty in the home. Such a common material as kerosene which in itself is certainly not a highly toxic material, accounts for many of the serious poisonings in children throughout the United States every year. Practically all of these cases are completely inexcusable in that mother or dad poured some kerosene into an ordinary drinking glass and then left it where a child could pick it up. This is certainly the most common pattern. Kerosene is not singled out here as a toxic substance, actually, just the reverse. Nearly any other organic fluid under the same circumstances would represent just as much of a problem and many of them vastly more. Actually, kerosene emphasized my point that the toxicity of a substance is not by any means the important part of the problem. Kerosene is among the least toxic of the organic fluids with which we would be concerned in the home. The problem is that it is one of the most common available and probably the most carelessly handled.

Think of the almost unlimited number of common substances used around the home: washing compounds, household insecticides, agricultural chemicals, disinfectants, dry cleaning materials, common solvents, natural gas, gasoline, turpentine, and many others. They vary in flammability and toxicity from potentially highly hazardous to almost innocuous, yet every one of them can be misused in some way. At the same time there is not one of them, no matter how hazardous it may be, that cannot be used with safety, if its properties are understood and it is handled with due consideration to its properties.

I could have given you a long dissertation on the detailed hazards of individual chemical substances and a tabulation of the various ways in which we could avoid difficulties. Practically all of this information has been published in some form. It appears in brief form on package labels and in more detail in the general literature. Much of this is already known to you. In analyzing the whole picture, it seems to me that, while this information is important, there is still the matter of convincing the people directly concerned to actually eliminate misuse. I have tried to discuss for you some of the more obvious angles of this problem of inducing people to apply some simple common sense to the handling of chemical substances in the industry and in the home.

We all recognize that it is possible with the proper knowledge and care to handle practically any substance, no matter how toxic or flammable. We also recognize that we can misuse nearly any substance so that there may be hazard to the health of individuals concerned. Our aim is not to eliminate materials from our industries or from our home because they may be flammable or toxic, but our aim is to eliminate careless or ignorant misuse so that you and I and everyone else can enjoy all the advantages of these substances.

The Part of the Industrial Hygienist in Compensation

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"THE PART of the Industrial Hygienist in Compensation Litigation" is a good long title for a talk, and it covers considerable territory. I want to break the subject down into two sections, and give you a few brief ideas on each. Remember, please, that I am speaking as a lawyer, and not as a hygienist. I am well aware that I see only a small part of the sum total of your work. Only where our paths happen to cross do we have the opportunity to get acquainted.

First, I want to tell you about your part in the preparation for trial, and then your part in the trial itself—the industrial hygienist as a witness. Before starting on these subdivisions, we should get together on a definition of terms, so we'll be discussing the same things. To me, for the purpose of this talk, industrial hygiene is used in the sense of the definition in the Encyclopedia Americana, 1947 edition: "The policy of providing healthful and comfortable working quarters for employees in commercial and manufacturing establishments."

This definition of course covers plant housekeeping as well as specific O. D. hazards. Thus, I am talking as well to personnel, mechanical, and executive departments as to medical, chemical and engineering hygienists.

Preparation for Trial

NOW TO the gist of the matter. First, the preparation for trial. It sounds as though I'm trying to perpetrate an epigram when I say that the best trial preparation you can possibly make is the prevention of claims. But I'm not trying to be either a humorist or the creator of a "bon mot." That statement is literally true. It just happens that the same kind of careful, scientific investigation that prevents claims also constitutes the most valuable evidence which your trial counsel wants for defense purposes. What are the data? In a recent paper issued by the American Management Association, DR. LEONARD J. GOLDWATER of New York gave the following suggestions: (1) Physical examinations, medical and dental; pre-employment, periodic, and terminal where possible; (2) Treatment of the workman to maintain a satisfactory health level; in other words, perhaps for minor non-occupational complaints as well as for accidents and O. D.; (3) Health education and health counseling; (4) Greater attention to mental hygiene; (5) Rehabilitation work, for the sick, injured, of long unemployed workman; (6) Records and statistics kept to discover dangerous operations, the habitually careless workman, and the workman with individual sensibility to industrial exposures.

I have not copied Dr. Goldwater in this tabulation, but have tried to include all of the factors which he proposed. This list is your work; you know what to do about it and how to go about it. I want to elaborate on just two of those points from a lawyer's viewpoint.

The discovery of physical handicaps is routine today. The growing problem is the pre-employment discovery of the mentally handicapped or susceptible applicant. Psychosomatic and psychoneurotic disability is becoming more prevalent daily, and is ever an increasing burden to industry. Perhaps I shouldn't say "becoming more prevalent;" I don't really believe that we are much, if any, crazier than our ancestors, or that our problems are any more burdensome to us than were theirs to them. It is, I believe, rapid advancement in the medical science, and especially in diagnostic methods by x-ray and clinical pathology, which have enabled the doctors to show that many complaints have no basis in the structures of the body, and that the cause is mental, emotional, and spiritual. They are no less real. In the handbook, "The Relation Between Injury and Disease," by Reed and Emerson, an excellent, non-technical description of the problem is presented:

"Some persons regard their situation so hopeless that they escape by suicide; others by developing spectacular psychogenic (mind-made) syndromes of organic disease; while others struggle on in situations

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which to them are unpleasant, distasteful, or apparently hopeless, until some injury, no matter how trivial, at once induces the development of a host of symptoms which save them from their unpleasant lot. Uncongenial employment is a very common reason for their development. The laborer who hates his work, his boss, his fellow workers, who feels that he is not appreciated or is not getting a square deal, may for months or years work on, each day hoping that something will happen to alter the situation. Then suddenly he sustains a minor accident because of which he must stop work for a few days. This affords him the relief for which he has long hoped. His trauma, however insignificant, like a percussion cap seems to touch off a whole train of symptoms. Without clear intent to deceive, unconsciously he makes the most of the situation by prolonging or aggravating his disability. The diagnosis in such cases is generally easy, but the identification of the patient's particular aversion often is difficult."

There is a real problem—to identify the psychoneurotic in advance, and not to give him the opportunity to unload his private cares, problems and worries onto your particular industrial shoulders. I realize that every applicant for employment cannot be psychoanalyzed, but a few minutes of careful personal interview reveals a world of information about the personality traits of the individual. Perhaps a simple questionnaire, whether along the lines of Dr. Crane's elemental newspaper quiz or of a more complicated form resembling a test for subconscious intelligence, could be devised. This is a problem for trained medical minds—I suggest only the desirability of a pre-employment mental, as well as physical examination. Not only would such a test pay dividends in reducing payment of claims, but in gathering together a more congenial, better satisfied, more cooperative, and hence more productive working force. Like the bad apple in the barrel, one misfit personality can spoil the production and safety record of an entire department.

Accumulation of Records

THE ACCUMULATION of adequate records plays a vital part in the preparation for trial of claims, especially occupational disease claims. A complete record of prior employments is invaluable. I cannot overstress the importance of pre-employment and regular chest x-ray in almost any plant; the importance of excretory analysis periodically; the importance of annual Wasserman examinations, since syphilis is a frequent cause of compensation claims; the careful periodic air dust count at designated points in the plant; the count of purposely undisturbed areas of residual dust at intervals; frequent inspection of, and servicing of grinding, spraying, exhaust, and respirator equipment. If you can hand the results of such examinations to your lawyer, he has no excuse for not putting forward the best possible defense to any claim for disability, whether based on occupational disease or residual disability from accidental injury. A pre-trial examination by the finest diagnostician, though desirable in any event, will be infinitely more effective when enhanced by background data. Without them the examiner is essentially a "fact" witness, reporting only what he found on a particular examination. True, he can express an opinion as to the cause and effect, but how much better if he can refer to carefully collated records and say "Here is the basis for my opinion." You may recall how Indian princes built a platform in a tree, then hire beaters to drive tigers to a clearing under the tree where they can be shot. If you want to do your tiger hunting on the spur of the moment, and are willing to beat the brush and take the chance of getting your tiger by the tail, or vice-versa, then don't bother to collect records. But if you'd rather build that platform in the tree, then collect your data before the event, not after. The hunt may not be as thrilling or as full of surprises, but remember that in a tiger hunt, most surprises to the hunter are likely to be unpleasant ones.

Collecting and Interpreting Data

ALONG THE lines of collecting and interpreting data, one other point should be mentioned. Expert as you men are, don't be too expert to call in some help occasionally. If assistance is not available immediately within the organization, try to convince management of the necessity and wisdom of going outside the organization. The safety engineer is going to need the advice

of a competent physician and probably of an industrial survey service. The plant physician may require occasional surveys by a mechanical engineer or of safety and ventilating equipment. The importance of correctly interpreting the data you compile should be obvious, but it is often the case that they are collected, filed, and forgotten. In his excellent monograph, "Medico-Legal phases of Occupational Diseases," DR. C. O. SAPPINGTON said: "The prime importance of adequate and intelligent interpretation of scientific information has already been discussed. Too often, rather than make the effort, untrained individuals attempt to translate highly technical reports with the expected results; mental indigestion, a confusion of ideas, and a misuse, abuse, or non-use of what might have been a pertinent application of valuable material."

When you have systematically, scientifically, and thoroughly collected and put to use the data on the physical condition of your plant and your workmen, you will have averted the vast majority of potential claims by clearing up the source. And when you have turned the data over to your company's lawyer with respect to a specific case, your work is almost complete. Almost, but not quite. You will be called upon to tell the court or the referee what those data are, how they were collected, and what they signify so far as they pertain to your special field of knowledge. That is my second point; I want to tell you something about how to act in the courtroom, or hearing room. We might call this preparation for the specific trial. Many of you have been witnesses, some perhaps on frequent occasions. Experience is a great teacher in the courtroom, for expert witnesses as well as for lawyers. I can only hope that I won't sound too primary for you who are old hands on the stand.

Lawyers can be rough or smooth; obvious or subtle; courteous or insulting. Many capable lawyers have the ability to adapt their techniques to the witness or to the end they wish to achieve.

Defense

THERE IS a common defense which will enable you to withstand all types of cross-examination. It consists of several steps. First, a conference with the lawyer on your side of the litigation prior to trial. Educate each other. He should have done some medical reading, but he won't become a doctor, a chemist, or an engineer as a result. Be sure he knows what your records show, and what the information may signify. Tell him if other records show unfavorable findings; he may be able to develop an explanation from other witnesses he intends to use. Be sure that he is fully acquainted with your professional background so that he may develop your qualifications, thus giving the greatest weight to your testimony. Remember that a man rarely takes the witness stand as an admitted expert. His qualifications are always subject to proof. No matter how eminent his reputation or how numerous his degrees, the doctor, the engineer, the architect can always be interrogated as to his experience and education in the subject under discussion. Especially is this true in a highly specialized field such as industrial medicine and hygiene. Your work and your qualifications are largely undefined, and are not officially known to the courts. I have searched through a little kind of a dictionary, a set of some forty volumes used by lawyers, called "Words & Phrases," searching for any legal opinion in which "industrial hygienist" has been defined. So far, no court has ever had occasion to tell the world just what you are and what you do. So far as I know, no state legislature has ever set up qualifications for industrial hygienists. You may be licensed professional engineers or licensed medical doctors, but your qualifications as industrial hygienists depend entirely on your own personal background, just as specialties like obstetrics in medicine, or petroleum chemistry depend on personal background, rather than on basic fundamentals known to all in the profession.

On the Stand

ONCE ACTUALLY on the stand, keep your mind alertly on the matter at hand. It is surprising how often witnesses, experts and otherwise, return answers which are entirely unresponsive to the question asked. If you don't understand the question, say so. Ask that it be read back, or clarified. Don't answer a question that doesn't mean anything to you. Before you answer a question, make sure the question makes sense.

If a "yes" or "no" answer is demanded, do your best to answer it, as nothing makes a poorer impression that an apparently evasive witness. However, you may and should insist on your right to explain that answer.

Show no bias or prejudice; if a certain fact or opinion is unfavorable to your side, your frankness in disclosing it will materilly increase the value of your favorable evidence. A good cross-examiner will bring it out anyway, so you may as well use it to *some* advantage. Above all, never lose your temper. It is nearly always taken as a sign that the witness cannot satisfactorily resist the examination on the basis of his expert knowledge. As the Chinese say, "He who strikes the first blow has lost the argument." It may further indicate a bias against the other side which is damaging, and I hardly need add that no matter how much you may know, and how valuable your technical knowledge might have been, your discretion as to use of language, and the operation of the thought process, are greatly impaired when you are seeing red.

Gentlemen, that is a smattering of a very large subject. It is a growing and important field of endeavor. In a time of class struggle and strife, you can do much more, you can help to keep society on an even keel. By exercise of your function, you can assist immeasurably in promoting happier and more contented working conditions and thus help to allay the bitter distrust and class feeling which threatens a democratic capitalistic system. By promoting the general health of the working man, you can demonstrate that private initiative and capital can and will do the job, and thus help in the battle to prevent government intervention in the field of private medical care. And finally, worth the effort alone and without any other reason being necessary, you can through the alleviation of injury and disease, avert a million heartaches, unrequired and useless suffering, and avoid much of the unnecessary wear and tear of industry on the human machine.

Some Environmental Aspects in the Construction of the City Tunnel

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BOSTON'S first attempt to improve the City's water supply occurred in the early Colonial days not many years after the settling of the area. In 1652 on petition of the inhabitants, a conduit was built near Dock Square. Dr. N. B. Shurtleff, in one of his articles on "Boston in the Olden Time," writes, "From what has been stated, it would appear that the conduit is a large reservoir, about 12 ft. square, made for holding water conveyed to it by pipes leading from neighboring wells and springs, for the purpose of extinguishing fires and supplying the inhabitants dwelling near it with water for domestic purposes."

Except for the construction of the Jamaica Pond Aqueduct which supplied water to 1,500 inhabitants of Boston and Roxbury, no further public action was taken until the passing of the Cochituate Water Act in 1846, authorizing the City of Boston to construct a public water supply, with an expenditure of 3 million dollars. An aqueduct of brick masonry would distribute a pure and wholesome water supply to the inhabitants of Boston. The introduction of fresh water to the Frog Pond in Boston Common on October 25, 1848, was the subject of a monstrous celebration.

As the population density increased in Boston and in the neighboring cities, there was a demand for more water. Other water sources were added to the system, necessitating construction of aqueducts from points further west so as to include the Wachusett and after that the Quabbin reservoirs. Considerable hard rock tunneling, construction of dams, dikes, etc., brought the modern water supply to Boston. The pressure aqueduct now known as the Hultman Aqueduct ended at Weston. Now under construction is a portion of the proposed City Tunnel which starts at the terminus of the Hultman Aqueduct in Weston at the Charles River, Riverside Pumping Station to the Chestnut Hill Pumping Station at the Boston-Brookline line. This section will be part of a loop system to furnish water to Metropolitan Boston, and, therefore, the present tunnel was designed with all the extensions in mind.

The present construction consists of 5.4 miles of rock tunneling and the sinking of four shafts (5, 6, 7, 7B) at a cost of nine million dollars. About 4.8 miles have a finished diameter of 12 feet, and 0.6 miles a finished diameter of ten feet. The diameter of the rough tunnels is approximately 2 ft. greater than the diameter of the finished tunnels. Construction started in December, 1947, and is expected to run for a contract time limit of 900 days. The construction crew numbers about 475 men. Tunnel driving operations continue on a three shift basis. These operations consist of drilling, loading the holes with explosive (usually a 60% gelatin dynamite), blasting by electrical detonation, and mucking. About 200,000 cubic yards will be excavated within the tunnel. The tunnel will be concrete lined.

Drilling

WORKING FROM the jumbo, each crew, operating six automatic drifters, drills an eight foot round with an average of 50 holes, each ten feet deep, during a two to two and a half hour period. It is possible to run two cycles so that a maximum exposure to the employees would be five hours of drilling. All drilling is done wet with a six inch water line running to the jumbo. A two inch compressed air line is used to bring air to the pneumatic drills. The men do not wear respirators. Ventilation is provided through a 24 inch diameter Naylor spiral pipe duct. The outlet of this duct is supposed to be located 30 feet from the drilling operation. However, during our visits the outlet was usually 80 feet away from the men.

The Naylor spiral pipe is assembled in 30 foot lengths. It runs from the powerhouse located above ground down the shaftway, then along the tunnel to the face of the tunnel. Each heading has its individual

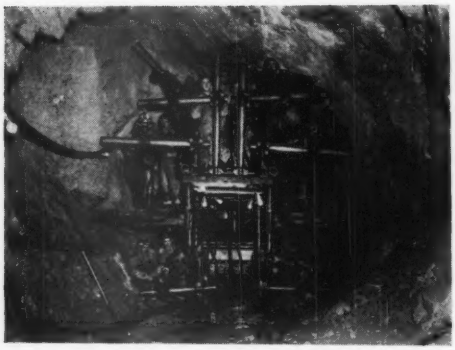

Fig. 1.
East heading of shaft No. 6, City Tunnel, Hultman Aqueduct. View of front end of drill Jumbo with drills in position for drilling heading

ventilating system. Ten thousand cubic feet of air per minute are delivered to each heading by blowers. The blowers are powered either by a 100, 125 or 150 horsepower motor and operate at 210 to 260 r.p.m. Static suction, depending upon the distance of travel of air through the duct, varies from two to four pounds. As the length of the heading increases, blowers are located within the heading for use when needed to insure an airflow of 10,000 cubic feet of air per minute.

The drilling has taken place through rock which has caused very little trouble and requires no shoring or bracing, except near Shaft No. 5, where a collapse of a small section of the tunnel roof occurred.

According to F. L. Tierney, geologist for the Metropolitan District Commission, Shaft No. 6 was driven through a conglomerate or sedimentary rock. This conglomerate or sedimentary rock contains material of pebble size, such as quartzite. The basic rock encountered in the east-west headings driven from Shaft No. 6 is known locally as melaphyre or andesite. The rock is found in the Andes Mountains in South America and also at this particular location in Newton, Massachusetts. It is similar to trap rock, devitrified magma, and is probably of volcanic origin. Melaphyre is considered a porphyritic rock consisting of phenocrysts (embedded crystals) of feldspar in a dark close-textured fine grain base. The rock in the heading of Shaft No. 7 is mostly argilite, which is a feldspar conglomerate rock with small amounts of quartzite, calcite and slate. Occasionally veins of quartzite, asbestos, magnesite, olivene and mineral serpentine are encountered. The veins are usually small and spotty. Occasionally beds or lenses of arkose, a type of sandstone, are encountered. The basic rock, melaphyre and argilite, are believed to have a low free silica content. Analyses of samples of rock indicate that the free silica content is approximately 10 per cent. However, it was also found on analysis that the free silica content may vary as much as 40%, dependent upon drilling through rock veins which contain material with a high free silica content.

In order to evaluate the dust hazard during drilling operations, samples of the dust-laden air were obtained with the M.S.A. midget impinger. It was found that in driving through rock such as melaphyre, with a free silica content of 10%, the dust count varied from 9 to 16 million particles per cubic foot of air. Subsequent sampling during the drilling through veins of rock which contained 40% free silica gave almost similar dust counts of 6 to 14 million particles per foot of air. The maximum allowable concentration for the rock containing 10% free silica is considered as 50 million particles per cubic foot of air, while that for rock containing 40% free silica is considered as 12.5 million particles per cubic foot of air. The maximum allowable concentration was exceeded slightly at times, for the high free silica-bearing rock. However, the drilling operation offers a dust exposure usually for two to two and a half hours and never more than five hours. The weighted average for the maximum exposure would be less than nine million particles per cubic foot of air.

As previously mentioned, the outlet of the ventilating duct was seldom less than 75 feet away from the drillers. It was recommended that the ventilating duct be extended at least an additional thirty feet. It was felt that bringing the duct closer to the drilling operation would increase the dilution of the contaminated atmosphere at its source, and would therefore reduce the dust concentration to well below the maximum allowable limit. Instead of blowing out the drilled hole with com-

pressed air, a long probe is inserted into the hole after the removal of the drill, and water at an elevated pressure is used to wash out the remaining dust. This procedure has eliminated one important source of atmospheric dust.

Blasting

AFTER approximately 50 holes are drilled, they are loaded with a total of 300 to 350 pounds of a 60% gelatin dynamite. The necessary detonators, wiring, etc., are connected in the usual way. The men are withdrawn from the face of the heading to a safe distance. The air flow in the ventilating duct is reversed for 15 minutes after the blast so that the air is exhausted from the drill heading.

Atmospheric samples for nitrous fumes were taken on several occasions after the blasting as the tunneling progressed.

TABLE 1
TYPICAL EXPOSURE TO NITROUS FUMES

	Time	Location	Oxides of Nitrogen P.P.M.
	8:30	Blast fired	
		Blower Exausting Air	
1	8:45	125 ft. from face of heading	10
2	9:00	90 ft. from face of heading	4
3	9:10	40 ft. from face of heading	25
		Blower Delivering Air	
4	9:28	25 ft. from face of heading	12
5	9:30	25 ft. from face of heading	6
6	9:55	25 ft. from face of heading	1

Based on the concentrations of oxides of nitrogen, a guide was developed which would indicate to the foremen when it would be safe for the men to resume operations at the face of the heading .

TABLE 2

Time After Blast	Safe Distance from Face of Heading (Based on Tests for Oxides of Nitrogen)
15 Minutes	125 ft.
30 Minutes	90 ft.
45 Minutes	50 ft.
60 Minutes	Face

Usually the men are withdrawn to such a distance from the face of the heading so that even though they may start to return to the work area immediately after the blast, sufficient time elapses so as to permit the ventilation to reduce concentrations of the nitrous fumes and other gases to a safe level. However, this was not always the case. At the time of a visit in May, 1949, the day crew had failed to reverse the booster blower in the tunnel heading prior to leaving at the end of the shift, with the result that practically no mechanical ventilation was supplied for a period of almost three-quarters of an hour after the blast. The smoke became so thick that it was impossible to sample further until the ventilation had been restored and the men were able to return to work. During the taking of these samples, a respirator with a cartridge for organic acid gases was worn by our chemist and seemed to give adequate protection. It was noted that the men occasionally entered the smoke-laden area using a dirty rag as protection against inhaling the fumes.

TABLE 3
EXPOSURE TO NITROUS FUMES

	Time	Location	Oxides of Nitrogen P.P.M.
	3:30	Blast fired	
1.	3:40	At edge of smoke cloud 150 ft. from face of heading	95
2	3:45	Same as 1	140
3	3:50	Same as 1	200
4	4:38	Same as 1, men entering work	20
5	4:42	Same as 1, men working	10
6	4:45	Same as 1	9

It was recommended that the time allowed for clearing the tunnel atmosphere before resuming work should be extended. Tests indicated that an additional 15 minutes would make a great difference in the concentration of the contaminants in the atmosphere. It was further recommended that, if it were deemed necessary for the men to enter the "gassed" area for a short period prior to the clearing of the atmosphere, they be provided with and required to wear a respirator approved by U.S. Bureau of Mines for organic acid gases. Also, if it is necessary to spend long periods of time within the gassed area, it is believed that the cartridge respirator would not provide adequate protection to the worker. It was recommended that for longer exposures gas masks equipped with an all-service cannister be worn.

Atmospheric samples for carbon monoxide were taken simultaneously with those for nitrous fumes, and the ratios of the concentration of one to the other were sim-

Fig. 2.
Looking westerly from shaft No. 6 showing planked invert and switches

ilar in all cases. For example, when it was found that the concentration of nitrous fumes was 10, the concentration of carbon monoxide in the atmosphere after blasting was approximately 100. Similarly, when the concentration of the nitrous fumes doubled or trebled, the concentration of carbon monoxide likewise doubled or trebled.

Several of the men indicated in casual conversation that they suffered considerably from frontal headaches which they attributed to fumes from the dynamite after blasting. They apparently considered the headaches as similar to those resulting from handling dynamite. Nevertheless, workers who had no actual contact with the explosive were among those who complained of the headaches which were relieved by inhaling or ingesting small doses of aromatic spirits of ammonia. It was thought possibly that undecomposed nitroglycerin was present in the atmosphere after the blast. Class No. 1 dynamite was used throughout the operation. Analyses of atmospheric samples indicated that there was no appreciable amount of nitroglycerin present in the samples. It is probable that carbon monoxide in conjunction with nitrogen dioxide was responsible. However, some of us still believe that nitroglycerin was partly responsible for the headaches because some of the men advised that during the "blowing-out" of holes containing misfires that the headache complaints by men in the immediate vicinity increased. We recommended that high pressure water be utilized for the flushing out of the misfires. When this method of removal of misfires was used, the number of headache complaints decreased to a minimum for this particular group of men. It is interesting to note that during the year 1948, over 750,000 lbs. of gelatin dynamite (60%) were used.

Mucking

SINCE ALL mobile equipment used within the tunnel was electrically powered, the usual contamination of the tunnel as encountered from the use of gasoline driven equipment was not present. The mucking machine is powered through a flexible power line extension cable while the muck car is powered by self-contained batteries. Proper maintenance and working practices assure a minimum risk from electric shock. The Conway shovel type mucking machine is self-propelled and travels on the same narrow gauge tracks as the muck cars.

The muck is literally saturated with water prior to its removal. Very little dust is dispersed during this operation. The average weekly progress of tunnel excavation per heading is approximately 170 linear feet.

As previously mentioned, occasional unsafe working practices usually resulted in the creation of an incident. Last winter, 1949, a request for immediate assistance was received by our Division, involving 24 men who had suffered headaches, dizziness and nausea while engaged in the pouring of the concrete shell in the finished section of the City Tunnel. The personnel of the Division were immediately rushed to the

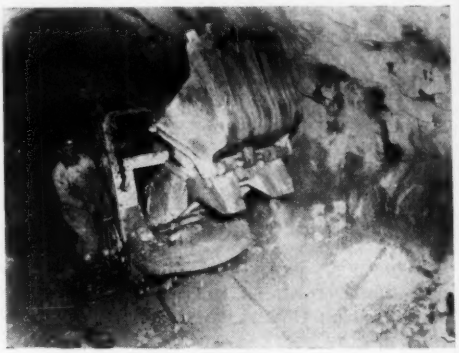

Fig. 3.
Looking easterly from west heading, shaft No. 6, showing Conway Mucker in operation

scene. Operations were stopped pending tests by members of the staff as well as by the engineers of the Metropolitan District Commission. Upon questioning of the workers, it was learned that during the swing shift of the previous day (4 to 12 midnight), in order to overcome the cold temperature in the tunnel, the men had lowered into the shaft a salamander containing live coke, from which most of the volatiles had been burned. The temporary diaphragm of the shaft opening was then replaced. Later a worker inadvertently added some soft coal to the heating unit, thereby causing the evolution of smoke and noxious gases. Seven workers became ill almost immediately, and seventeen men were affected at the beginning of the next shift and had to be sent home. Fortunately there were no cases involving loss of consciousness or loss of life. All operations were suspended in this portion of the tunnel until in the opinion of our staff the atmosphere was safe. Pending the arrival of the staff, the diaphragm was removed from the shaft opening and the tunnel was ventilated by natural circulation of the air. Tests were made for oxygen deficiency and carbon monoxide, both with negative results. Ventilation measurements indicated that approximately 5,000 c.f.m. were being circulated through the tunnel after the diaphragm had been removed.

Studies were also made of temperature and humidity in the various headings, particularly near the drilling operations. An average dry bulb of 58° to 60° F., wet bulb of 55° F. to 59° F., relative humidity of 80 to 98 per cent, and effective temperature of 57° to 60° were obtained. Since the average distance below the ground surface of the tunnel operations is about 250 feet, the temperature (dry bulb) becomes fairly constant and is affected only slightly by the forced air flow and wet drilling operation. This latter operation does affect the humidity and wet bulb readings because of the water mist dispersed into the tunnel atmosphere. However, the over-all readings may be considered as being fairly constant in comparison to the wide ranges in weather encountered above ground.

The noise intensities during drilling operations are such as to affect the hearing of visitors and new workers. These workers complain of tinnitus and minor headaches for about two weeks, after which they become "acclimated" to the noise. It is safe to assume that the noise intensity during the operation of the six pneumatic drifters was well above 100 decibels. During studies of the dust concentration due to drilling operations, it was necessary to wear ear plugs as protection against the noise.

As the tunneling operations progress, further studies of the environment as they relate to the health of the workers will be continued.

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3. Tunnel construction observed for hazards. *Industrial Hygiene Newsletter*, 8:10, October, 1948, p. 11.
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Conference Proceedings

Lead Hygiene Conference

THE PROCEEDINGS of the Lead Hygiene Conference held in Chicago in November, 1948, by the Lead Industries Association will be published on June 1 as a 137-page book with 33 illustrations. The contents are as follows:

Opening Address, Felix Edgar Wormser.

"Solubility and Particle Size in Lead Poisoning," Gordon C. Harrold, Ph.D. and Stuart F. Meek, M.D. Discussion, led by May R. Mayers, M.D.

"The Treatment of Lead Poisoning—Past and Present," David R. Johns, M.D. Discussion, led by William C. Wilentz, M.D.

"Preventive Medical Armor for the Lead Industry," F. B. Lanahan, M.D. Discussion, led by Elston L. Belknap, M.D.

"The Co-ordination of Industrial Medical Services," Sherman S. Pinto, M.D.

"Medical Control of Lead Workers—A State Viewpoint," John E. Silson, M.D. Discussion, led by Warren A. Cook.

"The Production Manager Looks at Industrial Health," Fred M. Gillies.

"The Effect of BAL on Experimental Lead Poisoning," Harry Eagle, M.D. Discussion, led by Alsoph H. Corwin, Ph.D.

"Air Pollution Regulations in Los Angeles County," Louis C. McCabe, Ph.D. Discussion, led by William N. Witheridge.

"Aluminum and Silicosis," John W. Berry, M.D. Discussion, led by O. A. Sander, M.D.

Summation of Conference Proceedings, Anthony J. Lanza, M.D.

Round Table Discussion.

"Urinary Porphyrins in Lead Poisoning," Gordon C. Harrold, Ph.D.

Single copies may be ordered from the Lead Industries Association, 420 Lexington Avenue, New York 17, N. Y., at $1.00 each. Quantity discounts to educational institutions will be quoted on request.

Air Pollution Symposium

PROCEEDINGS of the First National Air Pollution Symposium, November 10 and 11, 1949, Pasadena, California, sponsored by Stanford Research Institute in cooperation with California Institute of Technology, the University of California and the University of Southern California, are now available in a 149-page illustrated publication which includes the following papers:

"The Preparation, Collection, and Measurement of Aerosols," Dr. Victor K. LaMer.

"Determination of Concentration and Size of Particulate Matter by Light Scattering and Sonic Techniques," Dr. Frank T. Gucker, Jr.

"The Occurrence of Ice-Crystal Nuclei in the Free Atmosphere," Dr. Vincent J. Schaefer.

"A Continuous Recording Condensation Nuclei Meter," Dr. Bernard Vonnegut.

"Some Techniques for Sampling and Identifying Particulate Matter in the Air," Dr. W. D. Crozier and Ben K. Seely.

"National Trends in Air Pollution," Dr. Louis C. McCabe.

"Sampling of Industrial Stacks and Effluents for Atmospheric-Pollution Control," Dr. Leslie Silverman.

"Techniques Employed in the Analysis of Los Angeles Smog," Paul L. Magill.

"Some Instrumentation Problems in the Analysis of the Atmosphere," Dr. Harold W. Washburn and Dr. R. R. Austin.

"Reduction at the Source," Gordon P. Larson.

"Meteorology as a General Factor in Air-Pollution Problems," Norman R. Beers.

"Experimental Study of the Effect of Air Pollution on the Persistence of Fog," Dr. Hans Neuberger and M. Gutnick.

"Atmospheric Pollution Caused by the Diffusion of Waste Industrial Gases," Henry F. Hebley.

"Visibility and Air Pollution," Dr. Carsten C. Steffens, and Dr. Sylvan Rubin.

"The Economics of Air Pollution," Dr. Weldon B. Gibson.

"Air Pollution and Community Health," Dr. Robert A. Kehoe.

"Physiologic Effects of Chemical Contaminants of the Atmosphere," Dr. John H. Foulger.

"Effects of Fluorides on Man and Animals," Edward J. Largent.

"Impurities in the Air and Their Influence on Plant Life," Dr. P. W. Zimmerman.

"The Action of Sulphur Dioxide on Vegetation," Dr. Moyer D. Thomas, Russel H. Hendricks and George R. Hill.

"The General Problem of Air Pollution and Plants," Dr. Frits W. Went.

Single copies may be ordered from the Public Relations Office, Stanford Research Institute, Stanford, California, at $2.50 each.

At the Eleventh Annual Meeting, American Industrial Hygiene Association, Chicago, 1950. Seated left to right: Wiliam E. McCormick, Herbert T. Walworth, Philip Drinker, Anna Baetjer, E. C. Barnes, Henry F. Smyth, Charles Williams, and Robert Brown. Standing left to right: Thomas L. Shipman, Warren A. Cook, Carlton E. Brown, Theodore F. Hatch, L. M. Petrie, Allen D. Brandt, Bernard D. Tebbens, C. H. Mehaffey, A. G. Cranch, L. V. Taylor, and William G. Hazard

American Industrial Hygiene Association

—News of the Local Sections—

Chicago Section

ON MARCH 18, the program committee presented a panel discussion of topics and questions submitted by the members of the section. The Panel was composed of WARREN COOK of Zurich Insurance, JOAN M. TIMKE, R.N. of Bell & Howell Company, DR. JOSEPH HUBATA of Armour & Company, and JOHN YOUNG of International Harvester.

At the April 5 meeting, the Section was addressed by DR. HEDWIG KUHN of the Kuhn Clinic and KARL DUNN of Corning Glass Works. The subject of the speakers was "Industrial Eye Injuries."

The June 7 meeting is to be addressed by Frank E. Taylor, Chief Engineer, Brakeblock Division, American Brake Shoe Company, Detroit, on the subject "Industrial Hygiene in the Manufacture of Brake Lining."

Northern California Section

ON MARCH 31, DR. HERBERT K. ABRAMS gave a discussion on the subject of agricultural chemicals, pointing out that the general accident experience of agricultural workers was quite high and, in fact, in California was only exceeded by the construction industry and mining industry as a group. He stated that some 300 reports had been received during the past year of injuries due to the use of agricultural chemicals.

On April 18, OSCAR J. SOBOL, Industrial Hygienist of the U. S. Naval Air Station in Alameda, gave a paper on "Hazard Control in Radium Dial Painting." MR. SOBOL presented in detail the results of their efforts to make all operations pertaining to radium dial painting in instrument repair safe.

The regular meeting of this section was held on May 16 at El Cerrito. A brief discussion of the Annual Meeting of the Association was presented by LEON LEWIS, M.D., and BERNARD D. TEBBINS, SC.D., both of the Industrial Health Division of the University of California, School of Public Health, and by OSCAR J. SOBOL of the U. S. Naval Air Station at Alameda. The speaker of the evening was EDWARD E. DART, M.D., Consultant in Industrial Hygiene and Medical Director of the Battery Products Company. In discussing "Some Aspects of the Medical Control of Lead Poisoning," DR. DART pointed out that this occupational disease is still prevalent in many types of occupations. In addition to outlining symptoms to be looked for in physical examinations, he noted the various laboratory tests which are of value in diagnosis of the disease and in evaluation of the exposure. In addition,

he demonstrated blood testing methods.

The next meeting of this section is to be held on September 19, 1950.

Pittsburgh Section

ON MARCH 28, N. W. HARTZ of the Mine Safety Appliances Company addressed the meeting on the "Detection of Toxic and Explosive Gases." The speaker who is well qualified covered the important phases of this field.

On May 22, T. F. HATCH presented his impressions of his recent trip to Australia where he attended the Silicosis Conference at Sydney.

Brief reports on the National Meetings at Chicago were also given.

Baltimore-Washington Section

ON MAY 3, CHARLES R. WILLIAMS, PH.D., Director of Applied Research, Liberty Mutual Insurance Company, Boston, Massachusetts, spoke on "Some Problems of Atmospheric Pollution and Damage to Property and Live Stock in Areas Surrounding Industrial Plants."

This program was in keeping with the opening of the United States Technical Conference on Air Pollution.

Metropolitan New York Section

THE MARCH meeting was held at the Hotel Statler, New York City, in conjunction with the Greater New York Council's 20th Annual Safety Convention, March 28, 29, 30 and 31. Three sessions were devoted to Engineering, Chemical and Medical phases of Industrial Hygiene.

The three sessions of the Convention were, as follows:

1. Tuesday, March 28
   Fundamentals of Exhaust Systems
   (a) Design, Maintenance and Testing—W. B. HARRIS
   (b) Dust Collectors and Separators—JOHN M. KANE
   (c) Exhaust Hoods—B. F. POSTMAN
2. Friday, March 31
   Industrial Health—Chemical Phases
   Panel Discussion of Chemical Phases of Atmospheric Contamination
   Participants—J. W. FEHNEL, M. A. FISHER, M. G. GRAY, M. B. JACOBS and K. H. ROLL
3. Friday, March 31
   Industrial Health—Medical Phases
   (a) Oxygen Therapy in Exposure to Irritants—A. L. BARACH, M.D.
   (b) Effect of Sub-Micron Size Dust Particles—A. J. BORWALD, M.D.
   (c) Cooperation between Medical and Safety Departments—C. W. MCKINLEY, M.D.

For the May meeting, ten papers were given by members of the United States Technical Conference on Air Pollution. Each speaker presented various phases of the air pollution problem.

Michigan Section

AT THE MEETING held in Detroit on May 16, the highlights of the Annual Meeting of the Association were commented upon by CAREY P. MCCORD, M.D., Consultant Editor of Industrial Medicine and Surgery, and by FRANK A. PATTY, Director, Industrial Hygiene Service, General Motors Corporation. The following officers were elected: President, J. C. RADCLIFFE; President-Elect, R. G. SMITH; Secretary-Treasurer, V. B. SARKISSIAN, Executive Committee—Two year term: F. E. TOTH, DR. CAREY P. MCCORD, H. E. JAWORSKI, and F. T. MCDERMOTT. Executive Committee—One year term: MISS E. KILMER, and MRS. K. KUMLER. Executive Committee, previously elected: DR. IRA AVRIN, DR. EARL LUTZ, and D. G. FOWLER.

Southern California Section

THE FIRST general meeting of this section was held on February 23, 1950 in Los Angeles. DR. FRED A. BRYAN, President of the Section, exhibited a sound color movie on radiation monitoring, which had just been produced by the staff of the Atomic Energy Project, U.C.L.A.

At a second meeting on May 16, 1950, the subject "Solvents and Degreasers" was discussed by the following speakers: R. B. CARLISLE, Pacific Coast Manager, Detrex Corporation, who showed part of a sound slide film on the design and engineering aspects of vapor degreasers; E. W. MCGOVERN, West Coast Manager, Electrochemical Department, E. I. DuPont & Company, who reviewed the uses and properties of chlorinated solvents produced by his firm, with special reference to drycleaning and degreasing applications; ROBERT BENSHOOF, Safety Engineer, California Division of Industrial Safety, who described typical cases where inadequacies of engineering controls resulted in injury to exposed workers.

A short review of the Annual Meeting of the Association was presented by MARY MULVIHILL, R.N., RUTHERFORD T. JOHNSTON, M.D., Consultant in Industrial Health, and by ALRED M. NOYES of the Los Angeles City Health Department, Division of Industrial Hygiene.